

LISTING OF THE CLAIMS:

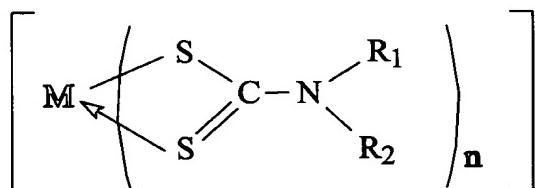
Claims 1-8 (Canceled)

Claim 9 (Currently Amended): A An aqueous lubricant comprising an aqueous liquid
and at least one multi-ligand metal chelate compound comprising, said compound having the
following structure:

at least one metal species selected from the group consisting of zinc, manganese, iron, molybdenum, tin and antimony, the metal species having multiple coordinating sites;

at least one polydentate chelate ligand having sulfur as a coordinating atom, the at least one ligand coordinating to at least one of the multiple coordination sites of the at least one metal species and having a formula selected from the group consisting of the following formulas (A) to (S):

(A)



wherein R₁ is the same as or different from R₂,

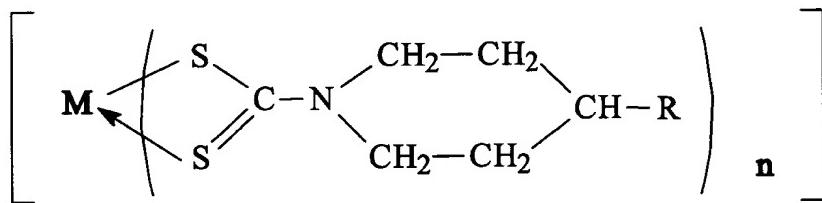
wherein when R₁ and R₂ are the same, each of R₁ and R₂ is H, -CH₃, -C₂H₅, -C₃H₇ (straight chain), iso-C₃H₇, -C₄H₉ (straight chain), iso-C₄H₉, tert-C₄H₉ or -C₆H₅, and

wherein when R₁ and R₂ are different, R₁ is H and R₂ is -CH₃, -C₂H₅, -C₃H₇ (straight chain), iso-C₃H₇, iso-C₄H₉, tert-C₄H₉ or -C₄H₉ (straight chain); or R₁ is -CH₃ or -C₂H₅ and R₂ is -C₆H₅,

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(B)

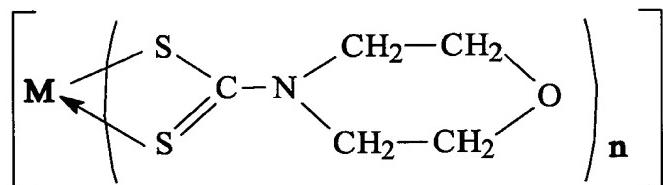


wherein R is H, -CH₃ or -C₂H₅, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

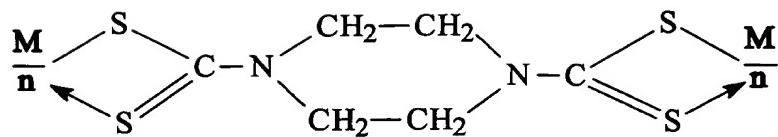
(C)



wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

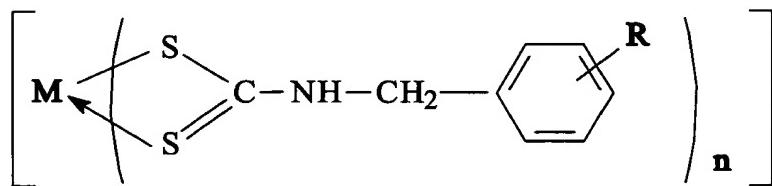
(D)



wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(E)

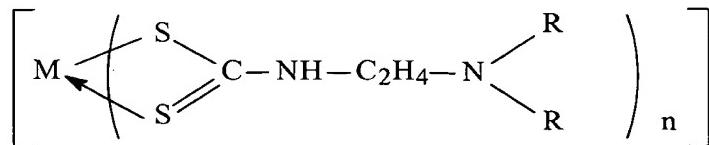


wherein R is ortho-NO₂, para-NO₂, meta-OCH₃, meta-CH₃ or meta-C₂H₅, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(F)

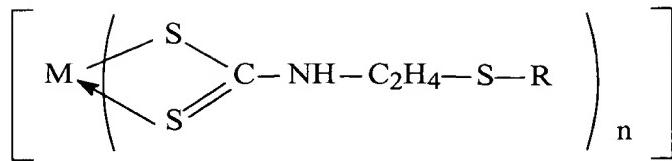


wherein R is -CH₃, -C₂H₅, -C₃H₇ (straight chain) or iso-C₃H₇, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(G)

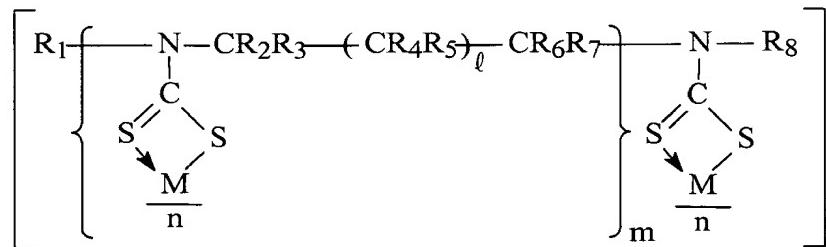


wherein R is H or an alkyl group of 1-12 carbon atoms, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(H)



wherein when m is 1 and l is 0, R₁-R₃ and R₆-R₈ are H; or R₁ is -CH₃ and R₂-R₃, R₆-R₈ are H; or R₁ is -C₂H₅ and R₂-R₃, R₆-R₈ are H; or R₁ is -C₃H₅ (straight chain) or iso-C₃H₅ and R₂-R₃, R₆-R₈ are H; or R₁ is -C₄H₉ (straight chain), iso-C₄H₉ or tert-C₄H₉, and R₂-R₃, R₆-R₈ are H; or R₂ and R₃ are -CH₃ and R₁, R₆-R₈ are H; or R₂ and R₆ are -CH₃ and R₁, R₃, R₇-R₈ are H; or R₂, R₃, R₆ and R₇ are -CH₃ and R₁ and R₈ are H; or R₁ and R₈ are -CH₃ and R₂-R₃, R₆-R₇ are H; or R₁ and R₈ are -C₂H₅ and R₂-R₃, R₆-R₇ are H; or R₁ and R₈ are -C₃H₅ (straight chain) or iso-C₃H₅ and R₂-R₃, R₆, R₇ are H; or R₁ and R₈ are -C₄H₉ (straight chain), iso-C₄H₉ or tert-C₄H₉, and R₂-R₃, R₆-R₇ are H; or R₂ and R₆ are -C₆H₅ and R₁, R₃, R₇-R₈ are H, and wherein when m is 1 and l is 1, R₁-R₈ are H; or R₄ and R₅ are -CH₃ and R₁-R₃, R₆-R₈ are H, and

wherein when m is 1 and ℓ is selected from 2, 3, 4, 5, 6 and 7, R₁-R₈ are H, and

wherein when m is selected from 2, 3, 4, 5, 6, 7, 8 and 9 and ℓ is 0, R₁-R₈ are H; or R₂

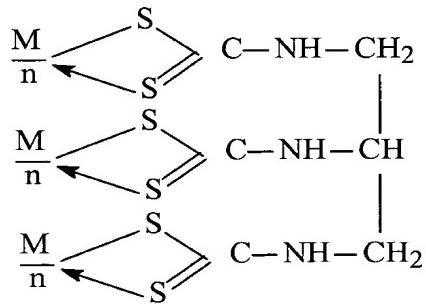
is -CH₃ and R₁, R₃, R₆-R₈ are H, and

wherein when m is selected from 2, 3, 4, 5, 6, 7, 8 and 9 and ℓ is 1, R₁-R₈ are H, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

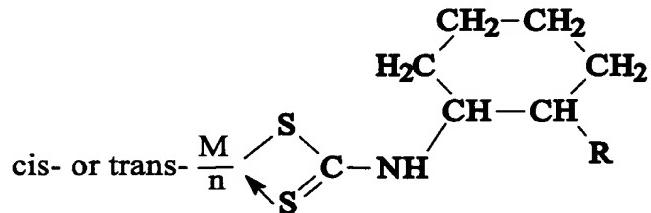
(I)



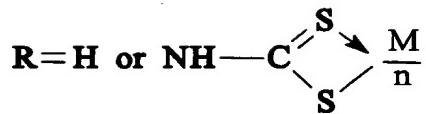
wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(J)



wherein

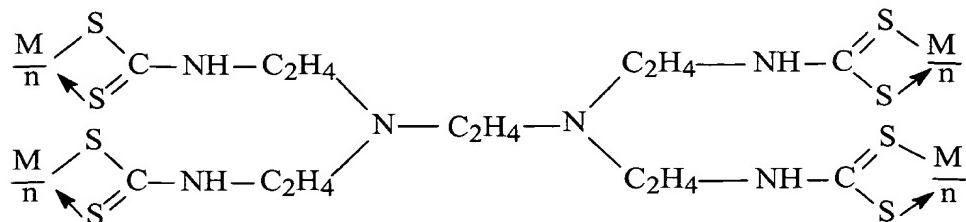


and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

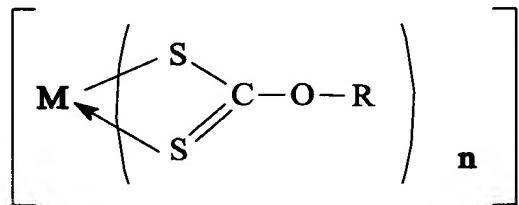
(K)



wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(L)

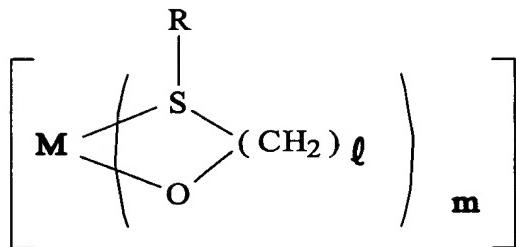


wherein R is a linear or branched alkyl group of 1-12 carbon atoms, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(M)

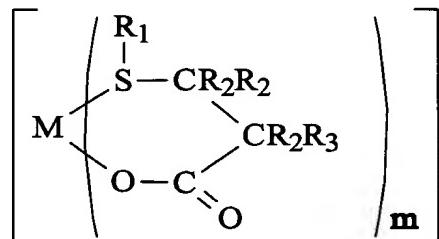


wherein R is H and ℓ is selected from 2 and 3; or R is an alkyl group of 1-12 carbon atoms and ℓ is selected from 2 and 3, and

wherein when M is zinc, molybdenum, tin or antimony, m is 1, and

wherein when M is manganese or iron, m is 1 or 2,

(N)

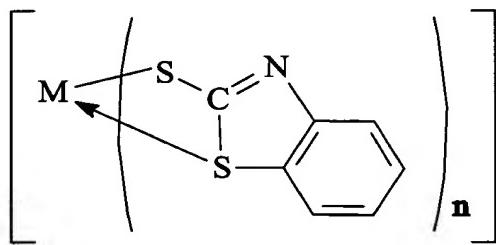


wherein R₁-R₃ are H; or R₁ is an alkyl group of 1-12 carbon atoms, R₂-R₃ are H; or R₁-R₂ are H, R₃ is -NH₂, and

wherein when M is zinc, molybdenum, tin or antimony, m is 1, and

wherein when M is manganese or iron, m is 1 or 2,

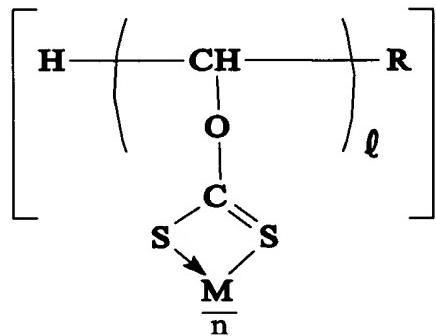
(O)



wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(P)

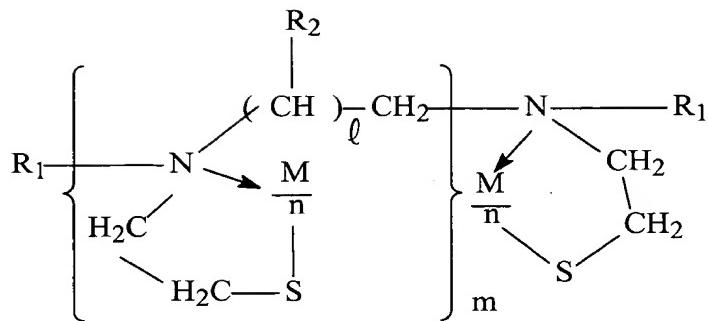


wherein ℓ is selected from 1, 2, 3, 4, 5 and 6, R is H or -COOH, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

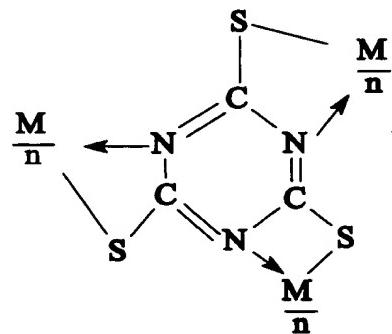
wherein when M is manganese or iron, n is 1 or 2,

(Q)



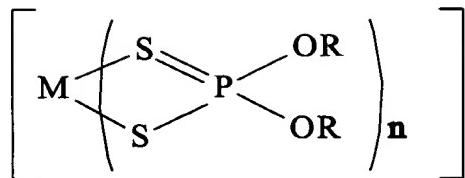
wherein R_1 and R_2 are H , ℓ is 1 or 2, m is selected from 1, 2, 3, 4, 5 and 6; or R_1 is $\text{C}_2\text{H}_4\text{S}^-$, R_2 is H , ℓ is 1 or 2, m is selected from 1, 2, 3, 4, 5 and 6, and
wherein when M is zinc, molybdenum, tin or antimony, m is 1, and
wherein when M is manganese or iron, m is 1 or 2,

(R)



wherein when M is zinc, molybdenum, tin or antimony, m is 1, and
wherein when M is manganese or iron, m is 1 or 2, and

(S)



wherein R is an alkyl group having one to twelve carbon atoms, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2;

and

at least one condensed phosphate and/or polyoxy carboxylic acid coordinated to the remaining coordination sites.

Claim 10 (Currently Amended): An aqueous lubricant comprising as in claim 9,
wherein the multi-ligand metal chelate compound is according to claim 9, suspended or dispersed in an aqueous liquid.

Claim 11 (Previously Presented): An aqueous lubricant as in claim 10, further comprising a soluble condensed phosphate salt, a fatty acid sodium salt, a fatty acid potassium salt and/or a soluble polycarboxylic acid salt.

Claim 12 (Previously Presented): A method of forming a lubricating film on a metal material comprising:

forming a phosphate film on the metal material, the phosphate film comprising zinc and/or iron ions; and

immersing the metal material in the aqueous lubricant of claim 10, whereby a ligand not having sulfur as a coordinating atom reacts with the zinc and/or iron ions in said phosphate film.

Claim 13 (Previously Presented): A method as in claim 12, wherein a crystalline polynuclear metal chelate compound is formed on the phosphate film.

Claim 14 (Previously Presented): A method of forming a lubricating film on a metal material comprising:

forming a phosphate film on the metal material, the phosphate film comprising zinc and/or iron ions; and

immersing the metal material in the aqueous lubricant of claim 11, whereby a ligand not having sulfur as a coordinating atom reacts with the zinc and/or iron ions in said phosphate film.

Claim 15 (Previously Presented): A method as in claim 14, wherein a crystalline polynuclear metal chelate compound is formed on the phosphate film.

Claim 16 (Previously Presented): A method of forming a lubricating film on at least one surface selected from a metal material surface and a metal mold surface, comprising applying the aqueous lubricant of claim 10 to the at least one surface.

Claim 17 (Previously Presented): A method as in claim 16, further comprising drying the at least one surface after application of the aqueous lubricant.

Claim 18 (Previously Presented): A method as in claim 17, further comprising plastically working the metal material.

Claim 19 (Previously Presented): A method as in claim 18, further comprising contacting the dried aqueous lubricant with a soluble condensed phosphate salt and/or a soluble polyoxycarboxylic acid salt before plastically working the metal material.

Claim 20 (Previously Presented): A method of forming a lubricating film on at least one surface selected from a metal material surface and a metal mold surface, comprising applying the aqueous lubricant of claim 11 to the at least one surface.

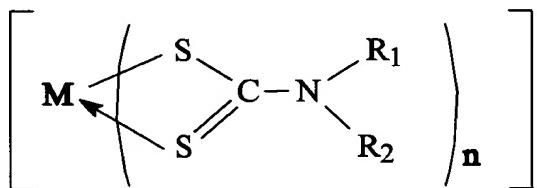
Claim 21 (Previously Presented): A method as in claim 20, further comprising drying the at least one surface after application of the aqueous lubricant.

Claim 22 (Previously Presented): A method as in claim 21, further comprising plastically working the metal material.

Claim 23 (Previously Presented): A method as in claim 22, further comprising contacting the dried aqueous lubricant with a soluble condensed phosphate salt and/or a soluble polyoxy carboxylic acid salt before plastically working the metal material.

Claim 24 (Currently Amended): A An aqueous lubricant comprising an aqueous liquid and at least one compound comprising, said compound having the following structure:
at least one multi-valent metal ion selected from the group consisting of zinc, manganese, iron, molybdenum, tin and antimony,
at least one polydentate chelate ligand having at least two sulfur atoms as coordinating atoms, the at least two sulfur coordinating atoms being bound to the at least one metal ion, the at least one ligand having a formula selected from the group consisting of the following formulas (A) to (L), (O), (P) and (S):

(A)



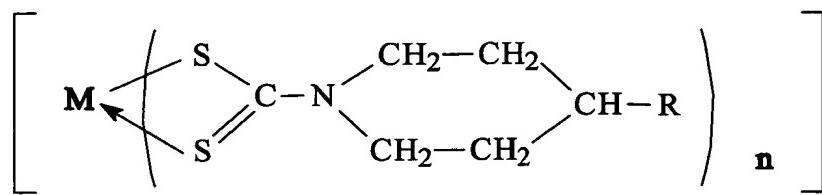
wherein R₁ is the same as or different from R₂,

wherein when R₁ and R₂ are the same, each of R₁ and R₂ is H, -CH₃, -C₂H₅, -C₃H₇ (straight chain), iso-C₃H₇, -C₄H₉ (straight chain), iso-C₄H₉, tert-C₄H₉ or -C₆H₅, and wherein when R₁ and R₂ are different, R₁ is H and R₂ is -CH₃, -C₂H₅, -C₃H₇ (straight chain), iso-C₃H₇, iso-C₄H₉, tert-C₄H₉ or -C₄H₉ (straight chain); or R₁ is -CH₃ or -C₂H₅ and R₂ is -C₆H₅,

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(B)

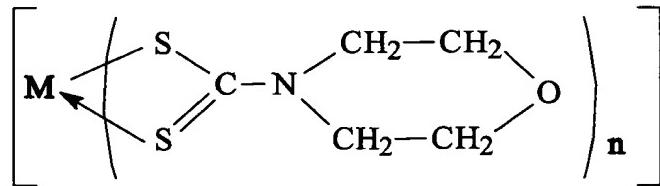


wherein R is H, -CH₃ or -C₂H₅, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

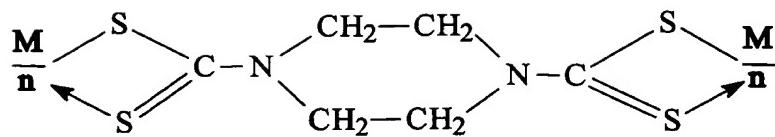
(C)



wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

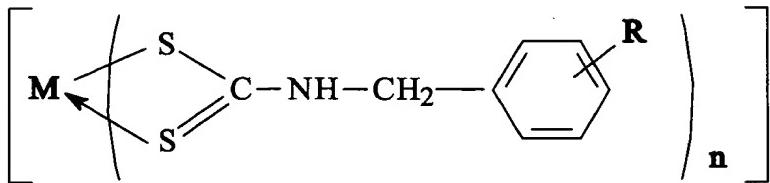
(D)



wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(E)

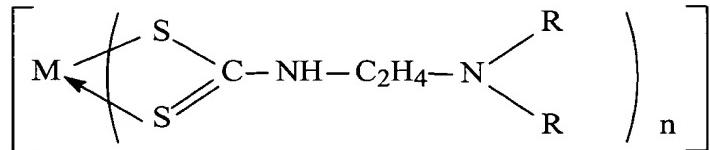


wherein R is ortho-NO₂, para-NO₂, meta-OCH₃, meta-CH₃ or meta-C₂H₅, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(F)

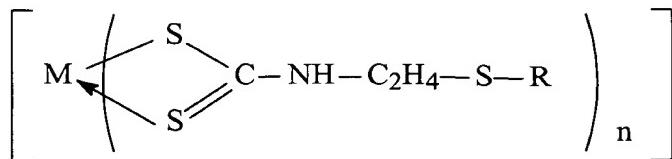


wherein R is -CH₃, -C₂H₅, -C₃H₇ (straight chain) or iso-C₃H₇, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(G)

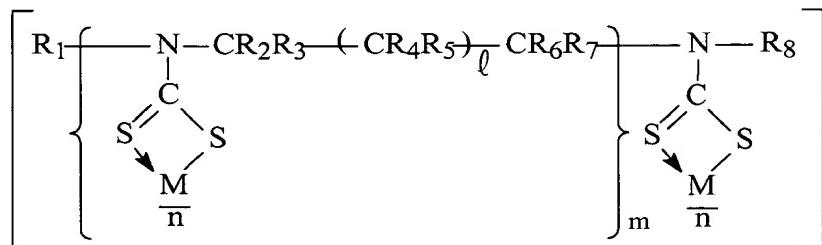


wherein R is H or an alkyl group of 1-12 carbon atoms, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(H)



wherein when m is 1 and l is 0, R₁-R₃ and R₆-R₈ are H; or R₁ is -CH₃ and R₂-R₃, R₆-R₈ are H; or R₁ is -C₂H₅ and R₂-R₃, R₆-R₈ are H; or R₁ is -C₃H₅ (straight chain) or iso-C₃H₅ and R₂-R₃, R₆-R₈ are H; or R₁ is -C₄H₉ (straight chain), iso-C₄H₉ or tert-C₄H₉, and R₂-R₃, R₆-R₈ are H; or R₂ and R₃ are -CH₃ and R₁, R₆-R₈ are H; or R₂ and R₆ are -CH₃ and R₁, R₃, R₇-R₈ are H; or R₂, R₃, R₆ and R₇ are -CH₃ and R₁ and R₈ are H; or R₁ and R₈ are -CH₃ and R₂-R₃, R₆-R₇ are H; or R₁ and R₈ are -C₂H₅ and R₂-R₃, R₆-R₇ are H; or R₁ and R₈ are -C₃H₅ (straight chain) or iso-C₃H₅ and R₂-R₃, R₆, R₇ are H; or R₁ and R₈ are -C₄H₉ (straight chain), iso-C₄H₉ or tert-C₄H₉, and R₂-R₃, R₆-R₇ are H; or R₁ and R₈ are -C₆H₅ and R₁, R₃, R₇-R₈ are H, and

wherein when m is 1 and ℓ is 1, R_1-R_8 are H; or R_4 and R_5 are $-CH_3$ and R_1-R_3 , R_6-R_8 are H, and

wherein when m is 1 and ℓ is selected from 2, 3, 4, 5, 6 and 7, R_1-R_8 are H, and

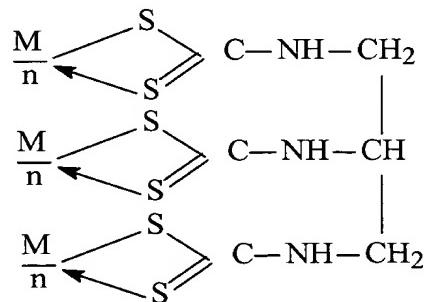
wherein when m is selected from 2, 3, 4, 5, 6, 7, 8 and 9 and ℓ is 0, R_1-R_8 are H; or R_2 is $-CH_3$ and R_1 , R_3 , R_6-R_8 are H, and

wherein when m is selected from 2, 3, 4, 5, 6, 7, 8 and 9 and ℓ is 1, R_1-R_8 are H, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

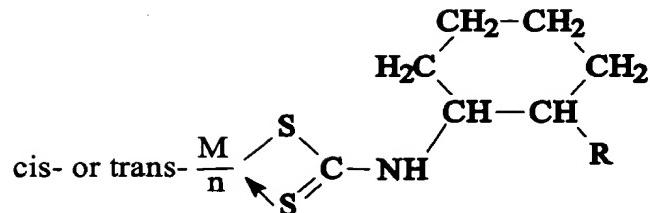
(I)



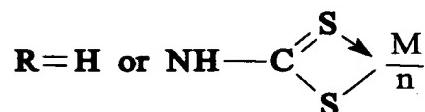
wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(J)



wherein

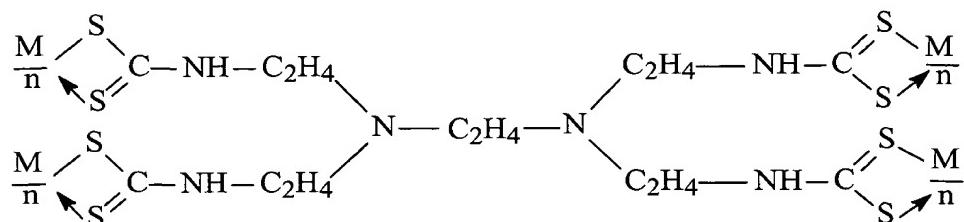


and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

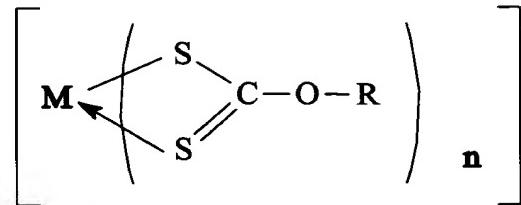
(K)



wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

(L)

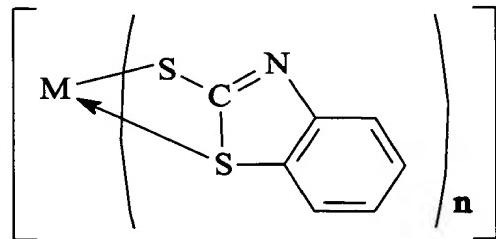


wherein R is a linear or branched alkyl group of 1-12 carbon atoms, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2,

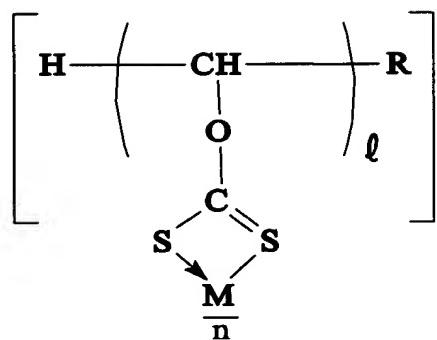
(O)



wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2, and

(P)

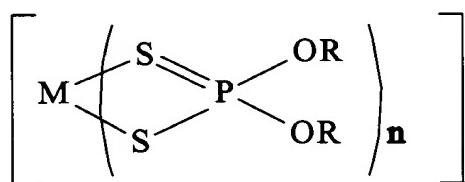


wherein ℓ is selected from 1, 2, 3, 4, 5 and 6, R is H or -COOH, and

wherein when M is zinc, molybdenum, tin or antimony, n is 1, and

wherein when M is manganese or iron, n is 1 or 2, and

(S)



wherein R is an alkyl group having one to twelve carbon atoms, and
wherein when M is zinc, molybdenum, tin or antimony, n is 1, and
wherein when M is manganese or iron, n is 1 or 2;
and

~~at least two other groups bound to the at least one metal ion, the groups selected from condensed phosphate and polyoxycarboxylic acid at least one condensed phosphate and/or polyoxycarboxylic acid coordinated with the metal.~~

Claim 25 (Currently Amended): An aqueous lubricant ~~comprising as in claim 24,~~
wherein the compound ~~of claim 24 is~~ suspended or dispersed in an aqueous liquid.

Claim 26 (Previously Presented): An aqueous lubricant as in claim 25, further comprising a soluble condensed phosphate salt, a fatty acid sodium salt, a fatty acid potassium salt and/or a soluble polyoxycarboxylic acid salt.

Claim 27 (Previously Presented): An aqueous lubricant as in claim 26, further comprising an anionic surfactant or a non-ionic surfactant, wherein the aqueous lubricant has a pH between 8-13.

Claim 28 (Currently Amended): A ~~compound~~ lubricant as in claim 24, wherein the at least one metal ion is a zinc ion and the at least two other groups bound to the zinc ion are selected from condensed phosphate and polyoxycarboxylic acid.

Claim 29 (Currently Amended): A ~~compound~~ lubricant as in claim 28, wherein the condensed phosphate is bound to the zinc ion and the condensed phosphate is tripolyphosphate.

Claim 30 (Currently Amended): A ~~compound~~ lubricant as in claim 29, wherein the polydentate chelate ligand is N,N-diethyldithiocarbamate.

Claim 31 (Currently Amended): A ~~compound~~ lubricant as in claim 24, wherein the polydentate chelate ligand is N,N-diethyldithiocarbamate.

Claim 32 (Currently Amended): A ~~compound~~ lubricant as in claim 31, wherein the condensed phosphate is bound to the at least one metal ion and the condensed phosphate is tripolyphosphate.

Claim 33 (Currently Amended): A ~~compound~~ lubricant as in claim 24, comprising two multi-valent metal ions.

Claim 34 (Currently Amended): A ~~compound~~ lubricant as in claim 33, wherein the condensed phosphate is tripolyphosphate.

Claim 35 (Currently Amended): A ~~compound~~ lubricant as in claim 34, wherein the polydentate chelate ligand is N,N-diethyldithiocarbamate.

Claim 36 (Currently Amended): A method of forming a lubricating film on a metal surface, comprising ~~mixing the compound of claim 24 with an aqueous liquid, thereby forming an aqueous lubricant~~, applying the aqueous lubricant of claim 24 to the metal surface and drying the metal surface after application of the aqueous lubricant.

Claim 37 (Currently Amended): A method of forming a lubricating film on a metal surface, comprising ~~mixing the compound of claim 29 with an aqueous liquid, thereby forming an aqueous lubricant~~, applying the aqueous lubricant of claim 29 to the metal surface and drying the metal surface after application of the aqueous lubricant.

Claim 38 (Currently Amended): A method of forming a lubricating film on a metal surface, comprising ~~mixing the compound of claim 35 with an aqueous liquid, thereby forming an aqueous lubricant~~, applying the aqueous lubricant of claim 35 to the metal surface and drying the metal surface after application of the aqueous lubricant.

Claim 39 (Canceled)

Claim 40 (Currently Amended): A ~~compound lubricant~~ as in claim 9, wherein the at least one metal species is selected from the group consisting of divalent zinc, divalent manganese, trivalent manganese, divalent iron, trivalent iron, tetravalent molybdenum, pentavalent molybdenum, divalent tin, tetravalent tin, trivalent antimony, and pentavalent antimony.

Claim 41 (Previously Presented): A lubricant as in claim 10, further comprising an anionic or non-ionic surfactant, wherein the aqueous lubricant has a pH between 8.0 and 13.0.

Claim 42 (Previously Presented): A lubricant as in claim 41, further comprising a soluble condensed phosphate salt, a fatty acid sodium salt, a fatty acid potassium salt and/or a soluble polyoxycarboxylic acid salt.

Claim 43 (Previously Presented): A lubricant as in claim 42, wherein the lubricant is substantially free of oil and organic solvents.

Claim 44 (Previously Presented): A method for forming a lubricating film on a metal surface, comprising applying the lubricant of claim 43 to the metal surface and drying the metal surface.

Claim 45 (Previously Presented): A method as in claim 44, wherein the metal surface is substantially free of oil.

Claim 46 (Previously Presented): A method as in claim 45, further comprising plastically deforming the metal.

Claim 47 (Currently Amended): A ~~compound~~ lubricant as in claim 9, wherein the at least one metal species is a zinc ion.

Claim 48 (Currently Amended): A ~~compound~~ lubricant as in claim 47, wherein the at least one condensed phosphate is tripolyphosphate and the ~~tripolyphosphate~~ tripolyphosphate is bound to the zinc ion.

Claim 49 (Currently Amended): A ~~compound~~ lubricant as in claim 9, wherein the at least one ligand is N,N-diethyldithiocarbamate.

Claims 50-57 (Canceled)